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Title: Comparison of Test Data Using Different Tools Available in W-13

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Comparison of Test Data Using Different Tools Available in W-13

Brittany Ouellette

7/14/2021

Purpose of this talk:

- Show progress on recent work performed in our team to answer system engineer's questions.
- Solicit feedback on metrics, suggestions on other test comparison examples
- Quasi “tool-time” to share two tools that fellow engineers in our group have developed and are using.

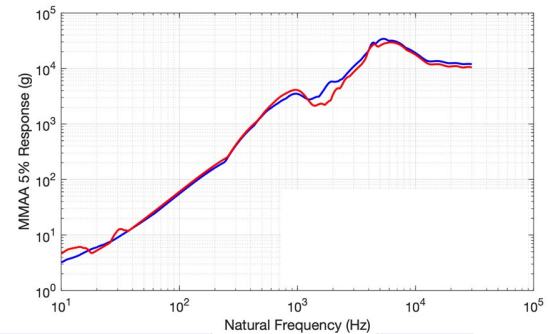
Why are we comparing two tests?

Our team (Isaac, Partha, Brittany) is building baseline models for both the legacy system and new configuration. **These models will be validated using test data.** We will be comparing improvements to our model against the test data, for both models. (MODEL-to- TEST)

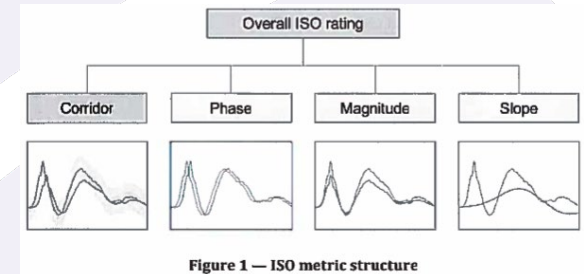
- System engineers also interested in how similar are the system responses to the legacy test (~2010) to the new configuration responses (2020-2021).
 - No previous studies done (that we are aware) where two similar impulse/LIHE tests were compared.
 - SNL reported side-by-side SRS plots for each sensor, but no quantitative comparison performed.
- **Test-Test Comparison** gives our team and the system engineering team an understanding of how varied similar Impulse /LIHE tests can be.

Initial Options for Comparing Test Data?

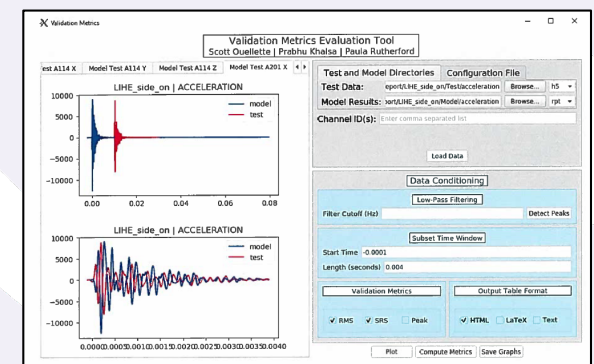
- Initial review: use SNL SRS curves to get a “warm fuzzy” that tests are in-family.
 - Qualitative
 - SME discussion with E-14
- But we want more....



- **Option 1: ISO 18571 Time-domain Evaluation**
 - Pro: developed specifically for test-test comparison
 - Pro: Code already scripted (Matt Fister)
 - Con: different type of signal/excitation



- **Option 2: Validation Metrics GUI**
 - Pro: We (W-13) already use this tool for model-test comparison
 - Pro: Threshold values already established for “good”, “fair”, and “poor” comparison
 - Con: meant for model to test comparison, needs adjustment of 2nd test data



ISO 18571 Brief Overview

- This Metric evaluation tool uses a weighted sum of 4 different metrics (below) comparing a “reference” and “test” to each other. The Corridor default weighting factor is 2X the other scores.

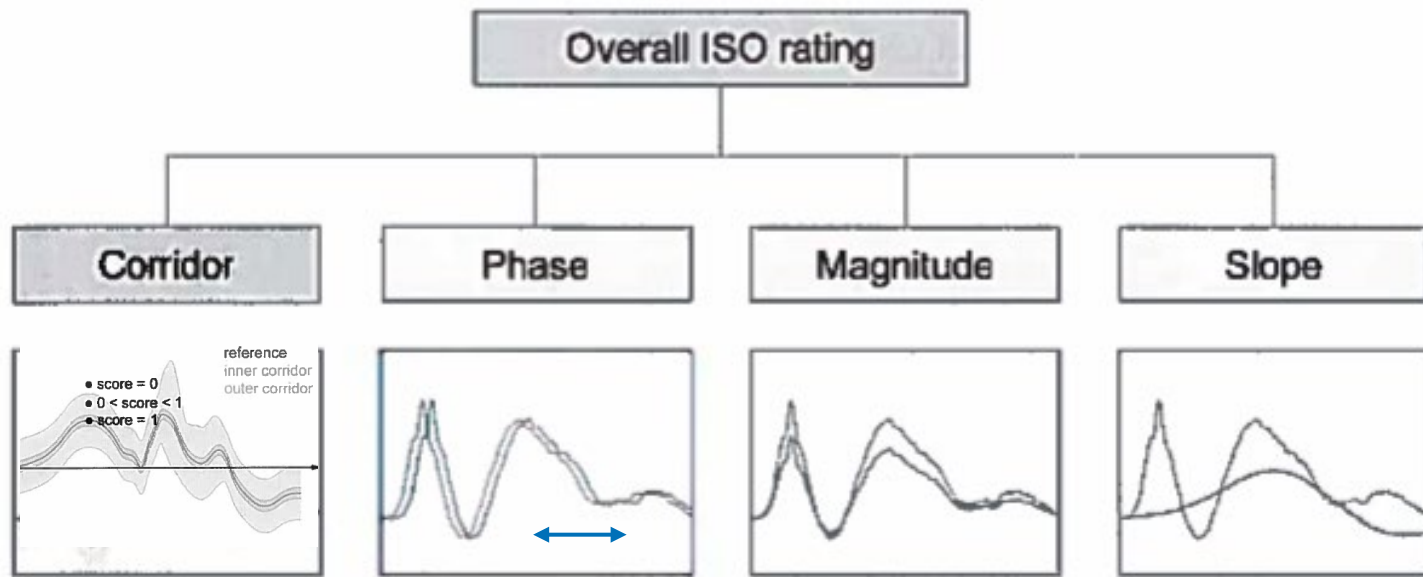


Figure 1 — ISO metric structure

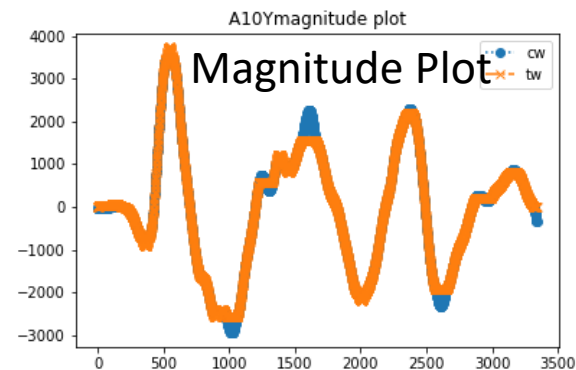
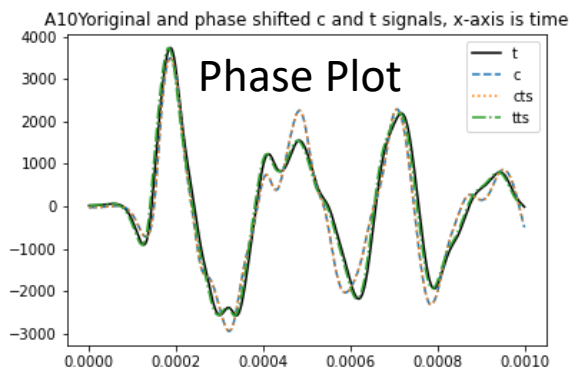
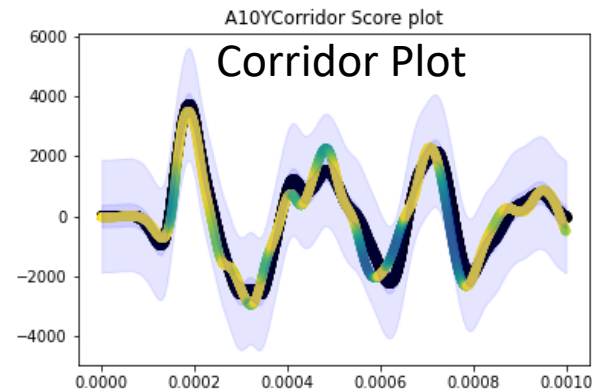
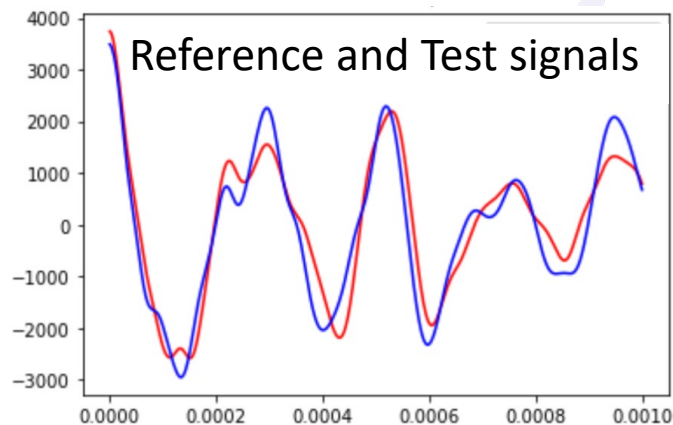
- Total score is then compared to threshold values (R).

Python script created by Matt Fister using ISO18571 document

Additional scripting used to condition data before using ISO 18571.

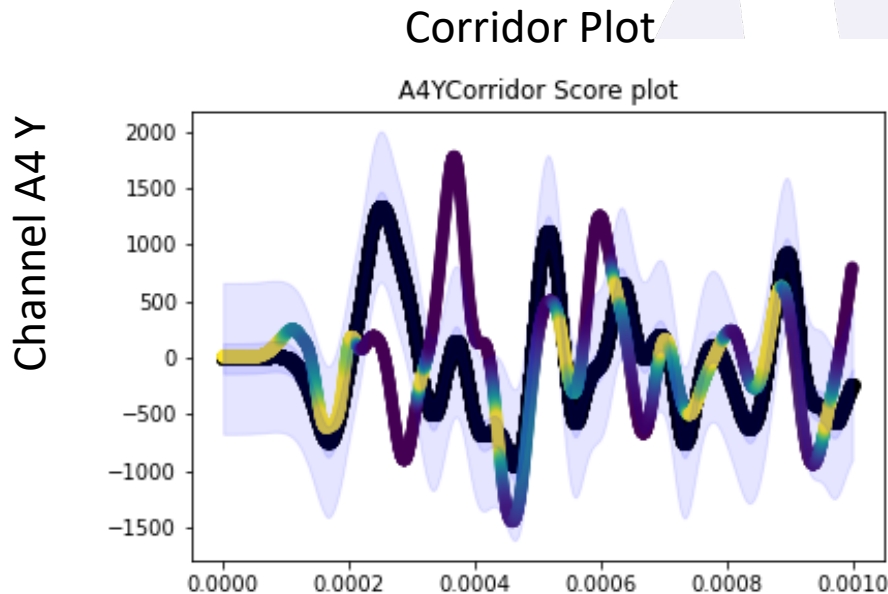
Example- A10Y channel

- Initial Time-shift done before any metrics are calculated. Time shift value held constant over entire test series.
 - Corridor score calculated BEFORE the phase shift. Corridor Score were all extremely low without this adjustment.
- A10Y is an example where the signals line up well visually, other accel readings not as similar. The score for this sensor and direction comparison was .88 (Good)



Other Example- A4Y channel

- A4Y channel comparison was given a score of 0.41, indicating “poor” comparison by using the default metric score ranges.



ISO 18571 Results on Impulse Testing

Not so great using default thresholds

- Most scores within “fair” to “poor” category
 - Only change to default parameters was inner corridor width increased from 0.05 to .1
 - Sampling frequency (SF), evaluation window different than example outlined in ISO document. Threshold ranges likely require changing to provide meaningful evaluation of comparison of data.
 - Data alignment done manually, thus phase score doesn’t provide much to this comparison.
- >> Modification needed to R values

Details	
Legacy Start	0
New Config Start	0
timing delay used	0
window length (ms)	1
a0 (inner corridor)	0.1
b0 (outer corridor)	0.5
kz (0 to 1 scaling)	2

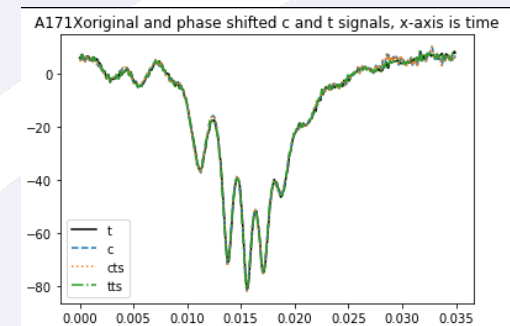
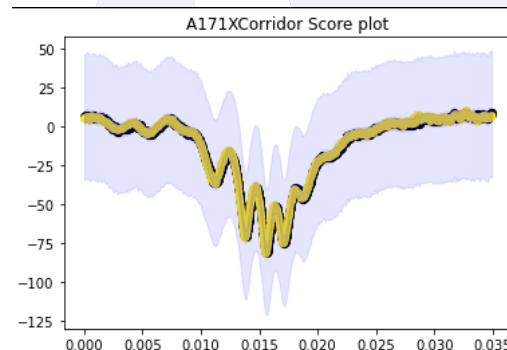
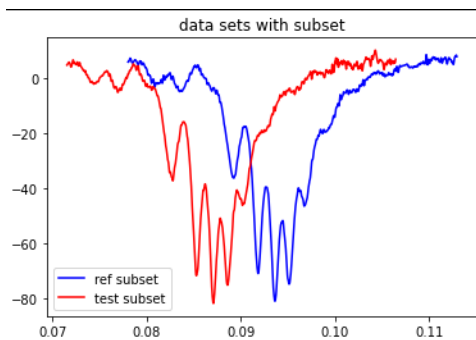
Thresholds		num
Excellent	$R > 0.94$	0
Good	$0.80 < R < 0.94$	7
Fair	$0.8 > R > .58$	25
Poor	$0.58 > R$	46

Channel	Iso Score	Corridor Score	Phase Score	Magnitude Score	Slope Score
A1X	0.765	0.748	0.949	0.723	0.656
A1Z	0.563	0.480	0.949	0.294	0.613
A3X	0.557	0.453	1.000	0.470	0.408
A3Y	0.503	0.411	0.848	0.438	0.408
A3Z	0.476	0.343	1.000	0.143	0.549
A4X	0.488	0.356	0.848	0.325	0.553
A4Y	0.221	0.304	0.495	0.000	0.000
A4Z	0.312	0.346	0.596	0.000	0.273
A8Y	0.461	0.253	0.899	0.516	0.385
A8Z	0.168	0.198	0.444	0.000	0.000
A9X	0.336	0.263	0.040	0.571	0.541
A9Y	0.609	0.501	0.798	0.637	0.608
A9Z	0.228	0.142	0.646	0.000	0.208
A10X	0.420	0.313	0.899	0.075	0.499
A10Y	0.666	0.589	0.899	0.578	0.675
A10Z	0.479	0.467	0.949	0.058	0.454
A11X	0.481	0.534	0.949	0.000	0.390
A11Y	0.549	0.465	0.949	0.343	0.521
A11Z	0.254	0.399	0.040	0.000	0.432
A50X	0.523	0.368	0.798	0.518	0.565
A101X	0.573	0.509	0.848	0.397	0.602
A101Y	0.451	0.500	0.949	0.000	0.306
A101Z	0.418	0.411	0.798	0.266	0.205
A102X	0.637	0.628	0.899	0.419	0.612
A102Y	0.467	0.384	0.899	0.070	0.598
A102Z	0.444	0.420	0.848	0.067	0.466
A103X	0.560	0.472	0.848	0.365	0.639
A103Y	0.394	0.347	0.747	0.023	0.505
A103Z	0.378	0.445	0.596	0.000	0.405
A113X	0.123	0.144	0.141	0.000	0.185
A113Y	0.264	0.268	0.394	0.000	0.392
A113Z	0.327	0.403	0.747	0.073	0.009
A114X	0.366	0.303	0.545	0.000	0.680
A114Y	0.336	0.387	0.798	0.000	0.108
A114Z	0.340	0.314	1.000	0.000	0.071
A398	0.290	0.085	0.747	0.000	0.535
A399	0.008	0.000	0.040	0.000	0.000
A541X	0.530	0.436	0.949	0.421	0.406
A541Y	0.608	0.534	1.000	0.395	0.577
A541Z	0.308	0.199	0.495	0.146	0.501
S101A	0.081	0.116	0.040	0.000	0.133
S102A	0.662	0.618	0.949	0.536	0.590
S103A	0.445	0.445	0.848	0.000	0.489
S107A	0.788	0.735	0.848	0.896	0.727
S107H	0.606	0.497	0.899	0.471	0.666
S108A	0.778	0.690	0.899	0.886	0.724

S147H	0.697	0.577	0.899	0.716	0.716
S148A	0.352	0.119	1.000	0.068	0.457
S148H	0.470	0.362	0.545	0.651	0.428
S149A	0.794	0.694	1.000	0.823	0.761
S203A	0.651	0.539	0.899	0.588	0.693
S207A	0.689	0.548	0.949	0.630	0.770
S209A	0.619	0.443	0.899	0.536	0.773
S209H	0.440	0.420	1.000	0.000	0.360
S211A	0.241	0.116	0.495	0.000	0.480
S211H	0.046	0.043	0.040	0.000	0.101
S213A	0.705	0.548	0.899	0.844	0.685
S213H	0.734	0.740	0.848	0.829	0.514
S215H	0.639	0.463	0.899	0.676	0.695
S219A	0.865	0.871	0.949	0.942	0.690
S219H	0.454	0.411	0.242	0.763	0.444
S221A	0.697	0.671	0.949	0.728	0.468
S221H	0.526	0.308	0.899	0.461	0.654
S224A	0.828	0.787	0.949	0.839	0.775
S224H	0.682	0.537	0.899	0.684	0.752
S225A	0.802	0.756	0.949	0.861	0.687
S225H	0.712	0.610	0.899	0.627	0.816
S226A	0.839	0.815	0.949	0.887	0.729
S226H	0.690	0.583	0.899	0.611	0.776
S227A	0.834	0.841	0.899	0.925	0.662
S227H	0.761	0.639	0.899	0.775	0.851
S229A	0.883	0.880	1.000	0.912	0.744
S229H	0.639	0.474	0.899	0.652	0.699
S231A	0.802	0.762	0.949	0.907	0.630
S231H	0.605	0.419	0.848	0.614	0.727
S242H	0.726	0.605	0.899	0.739	0.782
S243H	0.221	0.189	0.040	0.191	0.495
S399	0.219	0.301	0.495	0.000	0.000

Impulse Study of previous test-data: Drop Test

- Suggestion to review test data from a series of drop tests (different system, told this test body less complex).
 - Multiple drops at same height for either the same assembly, or supposed same builds of the assembly
 - Although a different response, drop tests are shock test, perhaps we can learn something about the similarity of tests and metrics.



Drop 50g Test 1 to 2 comparison w/ updated time shift and minized						
Phase plots are better, corridor score is slightly worse but benefits from the more						
Channel	Iso Score	Corridor Score	Phase Score	Magnitude Score	Slope Score	
A171X	0.785	0.870	0.891	0.911	0.383	
A172X	0.909	0.900	0.884	0.968	0.895	
A173X	0.886	0.888	0.884	0.898	0.871	
A174X	0.913	0.907	0.884	0.973	0.887	
A175X	0.154	0.000	0.449	0.000	0.321	
A176X	0.909	0.908	0.884	0.935	0.910	
A271X	0.899	0.918	0.876	0.972	0.811	
A272X	0.773	0.822	1.000	0.887	0.336	

Drop 100g Test 1 to 2 comparison w/ updated time shift						
Phase and corridor plots improved with more accurate shift						
Channel	Iso Score	Corridor Score	Phase Score	Magnitude Score	Slope Score	
A171X	0.787	0.818	0.990	0.854	0.457	
A172X	0.942	0.995	0.990	0.968	0.761	
A173X	0.939	0.988	0.990	0.946	0.782	
A174X	0.939	0.995	0.981	0.973	0.750	
A175X	0.282	0.137	0.771	0.000	0.365	
A176X	0.942	0.993	0.990	0.956	0.779	
A271X	0.946	1.000	0.990	0.976	0.762	
A272X	0.524	0.581	0.637	0.544	0.280	

Drop 150g Test 1 to 2 comparison w/ estimated time shift						
no adjustment needed						
Channel	Iso Score	Corridor Score	Phase Score	Magnitude Score	Slope Score	
A171X	0.925	0.971	0.971	0.932	0.781	
A172X	0.965	0.976	0.971	0.973	0.928	
A173X	0.964	0.974	0.971	0.974	0.923	
A174X	0.963	0.974	0.971	0.973	0.923	
A175X	0.226	0.013	0.933	0.000	0.171	
A176X	0.964	0.974	0.971	0.973	0.924	
A271X	0.909	0.996	0.971	0.971	0.610	
A272X	0.119	0.195	0.017	0.000	0.191	

Drop 50g Test 1 to 3 comparison w/ improved time shift						
Channel	Iso Score	Corridor Score	Phase Score	Magnitude Score	Slope Score	
A171X	0.821	0.941	0.963	0.888	0.364	
A172X	0.951	0.984	0.963	0.940	0.880	
A173X	0.951	0.994	0.963	0.954	0.845	
A174X	0.960	0.996	0.963	0.969	0.863	
A175X	0.273	0.032	0.984	0.000	0.317	
A176X	0.968	0.997	0.963	0.983	0.894	
A271X	0.936	0.999	0.969	0.969	0.744	
A272X	0.692	0.701	0.977	0.804	0.278	

Drop 100g Test 1 to 3 comparison w/ improved time shift						
Channel	Iso Score	Corridor Score	Phase Score	Magnitude Score	Slope Score	
A171X	0.856	0.958	0.981	0.930	0.452	
A172X	0.943	0.994	0.981	0.970	0.779	
A173X	0.934	0.978	0.981	0.930	0.801	
A174X	0.934	0.992	0.981	0.955	0.750	
A175X	0.390	0.058	0.036	0.336	0.261	
A176X	0.939	0.984	0.981	0.945	0.801	
A271X	0.934	1.000	0.990	0.970	0.710	
A272X	0.257	0.094	0.733	0.000	0.365	

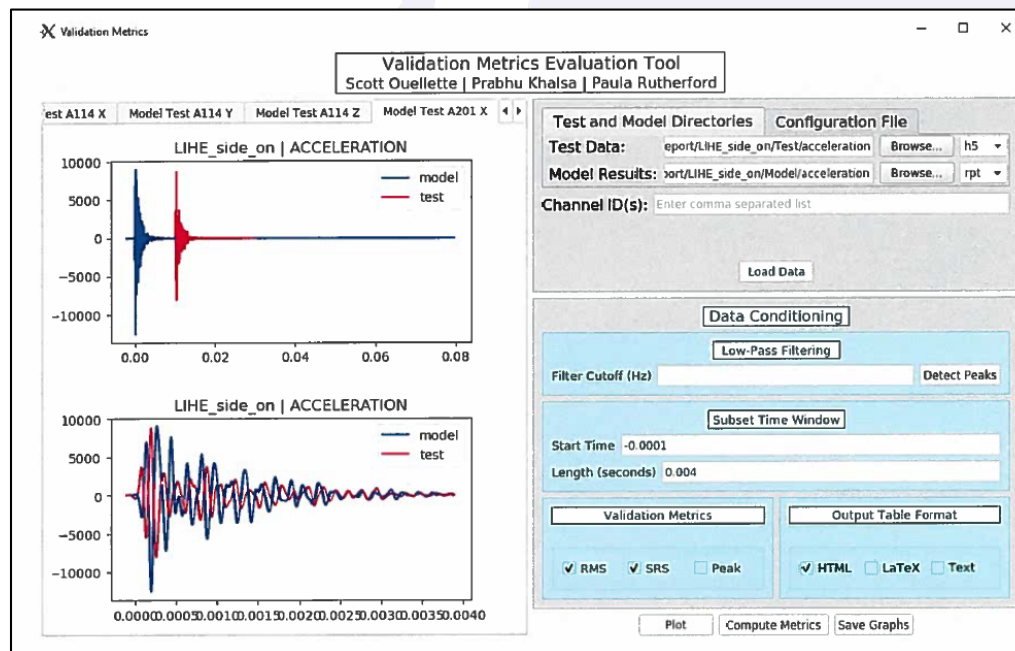
Drop 150g Test 1 to 3 comparison w/ improved time shift						
Channel	Iso Score	Corridor Score	Phase Score	Magnitude Score	Slope Score	
A171X	0.936	1.000	0.990	0.944	0.745	
A172X	0.984	1.000	0.990	0.978	0.952	
A173X	0.981	1.000	0.990	0.974	0.940	
A174X	0.980	1.000	0.990	0.973	0.939	
A175X	0.491	0.502	0.819	0.609	0.021	
A176X	0.986	1.000	0.990	0.983	0.956	
A271X	0.934	1.000	0.990	0.974	0.704	
A272X	0.320	0.150	0.847	0.153	0.297	

Validation Metrics GUI (VM GUI)

Metrics calculations and threshold values are used for model-to-test comparison in various systems.

Input: Abaqus report files, and h5 test data files. Compares ratios of RMS, SRS and Peak values between test and model data.

Metrics initially created(?) or documented use by Bob Stevens

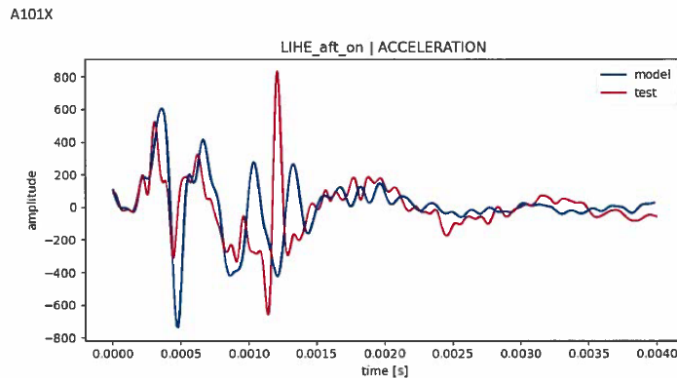


This tool is used for model-test validation, and uses thresholds created by this group.

Scripting and GUI created by Scott Ouellette, Prabhu Khalsa, and Paula Rutherford

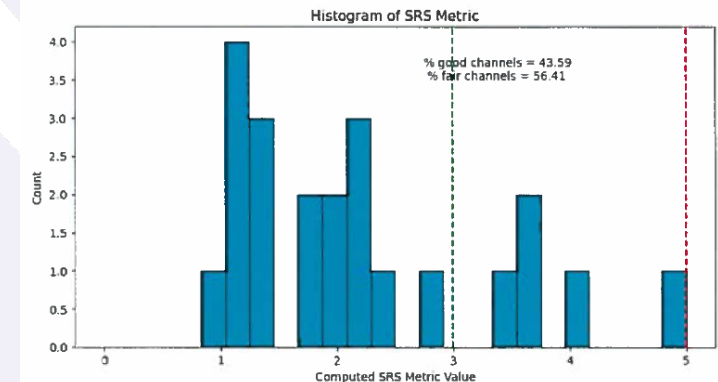
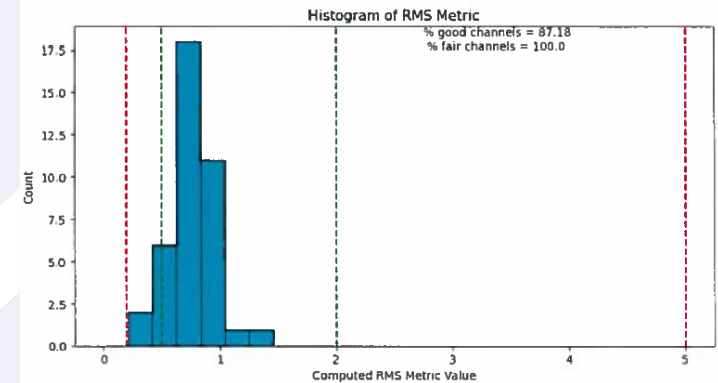
VM GUI- metric values shows better outcome of comparison

In order to use this tool, one set of test data (legacy) was converted into the units and file format of the abaqus report file. i.e. “fake model data”



Aft-on LIHe Legacy vs. new			
Window: 0.004 sec			
Channel	RMS	SRS	Comments
A101X	0.75	6.34	
A101Y	0.43	175.2	
A101Z	0.77	14.27	
A102X	0.98	1.42	
A102Y	1.04	3.63	
A102Z	0.8	9.97	
A103X	0.89	1.2	
A103Y	0.67	10.91	
A103Z	0.96	5.35	
A10X	1.03	1.14	
A10Y	1.05	2.87	
A10Z	0.8	2.19	
A113X	0.68	2.28	
A113Y	0.5	8.71	
A113Z	1.26	2.39	
A114X	0.86	1.73	
A114Y	0.48	18.29	
A114Z	0.8	1.36	
A11X	0.79	0.98	
A11Y	0.75	5.72	
A11Z	0.75	2.18	
A1X	0.77	1.07	
A1Z	0.52	14.79	
A3X	0.77	1.27	
A3Y	0.51	11.13	
A3Z	0.5	17.24	
A4X	0.98	1.1	
A4Y	0.63	8.35	
A4Z	0.78	1.94	
A50X	0.71	3.54	
A541X	0.99	1.92	
A541Y	0.91	6.52	
A541Z	0.86	4.09	
A8X	0.21	4.87	
A8Y	0.67	12.24	
A8Z	0.81	9.87	
A9X	0.79	3.55	
A9Y	0.96	1.71	
A9Z	0.21	17.4	

- 87% channels show good RMS comparison
- 43% of channels show good SRS comparison (70% of channels in direction of load)



Summary

- ISO 18571 Metrics
 - Helpful in that it was designed specifically to compare test data
 - Conditioning code written to use is single-use (in progress to make this more user-friendly for others to use, but isn't difficult to follow, or adjust)
 - Needs more insight into grading scale based on the type of response, Sampling rate and duration of time-window evaluated.
- VM GUI
 - Conditioning and windowing already part of the GUI, or config file for channels.
 - Does not support comparison of two h5 (test) files. Would require effort to add to the GUI in the future.
 - Threshold values already established and used for these types of tests.